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Summers and Ma Relativistic electrons in the inner magnetosphere

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# A MODEL FOR GENERATING RELATIVISTIC ELECTRONS IN THE EARTH'S INNER MAGNETOSPHERE BASED ON GYRORESONANT WAVE-PARTICLE INTERACTIONS

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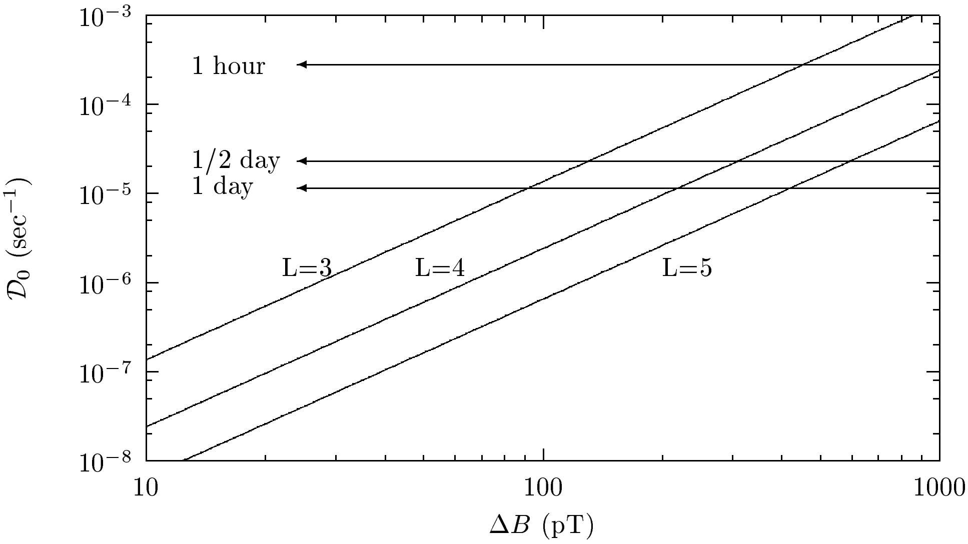
abstract During the recovery phase of a magnetic storm, fluxes of relativistic (> 1 MeV) electrons in the inner magnetosphere ($3 \leq L \leq 6$) increase to beyond pre-storm levels, reaching a peak about 4 days after the initiation of the storm. In order to account for the generation of these "killer electrons", a model is presented primarily based on stochastic acceleration of electrons by enhanced whistler-mode chorus. In terms of a quasi-linear formulation, a kinetic (Fokker-Planck) equation for the electron energy distribution is derived, comprising an energy diffusion coefficient based on gyroresonant electron-whistler-mode wave interaction and parallel wave propagation; a source term representing substorm-produced (lower energy) seed electrons; and a loss term representing electron precipitation due to pitch-angle scattering by whistler-mode waves and EMIC waves. Steady-state solutions for the electron energy distribution are constructed, and fitted to an empirically-derived relativistic Maxwellian distribution for the high energy "hard" electron population at geosynchronous orbit. If the average whistler amplitude is sufficiently large, for instance 75 pT – 400 pT, dependent on the values of the other model parameters, and assuming a background plasma density of $N_0 = 10$ cm$^{-3}$ outside the plasmasphere, then a good fit to the empirical distribution is obtained, and corresponds to a timescale for the formation of the high-energy steady state distribution of 3 – 5 days. For a lower representative value of the background plasma density, $N_0 = 1$ cm$^{-3}$, smaller whistler amplitudes, in the range 13 – 72 pT, can produce the high-energy distribution in the required time frame of several days. It is concluded from the model calculations that the process of stochastic acceleration by gyroresonant electron-whistler-mode wave interaction, in conjunction with pitch-angle scattering by EMIC waves, constitutes a viable mechanism for generating "killer electrons" during geomagnetic storms. The mechanism is expected to be particularly effective for the class of small and moderate storms possessing a long-lasting recovery phase during which many substorms occur.



$10^{-3}$
$10^{-4}$
$10^{-5}$
$10^{-6}$
$10^{-7}$
$10^{-8}$
$\mathcal{D}_0$ (sec$^{-1}$)
1 hour
1/2 day
1 day
L=3
L=4
L=5
10
100
1000
$\Delta B$ (pT)